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THE DAKOTA-PERMIAN CONTACT IN NORTHERN KANSAS, . *F. C. Greene.*

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THE DAKOTA-PERMIAN CONTACT IN NORTHERN KANSAS.

BY F. C. GREENE.

Plates I to IV.

INTRODUCTION.

DURING the summer of 1906, while working on the University Geological Survey of Kansas, under the direction of Dr. J. W. Beede, the Permian-Cretaceous contact in Kansas, north of the Smoky Hill river, was mapped. The most of the northern third of the region was mapped jointly with Doctor Beede and the remainder mapped individually, in alternate stretches.

The region covered in this account lies in Washington, Riley, Clay, Dickinson and Ottawa counties, and is included in the Washington, Marysville, Clay Center, Abilene, and a corner of the Minneapolis topographic sheets of the U. S. Geological Survey. The area lies in the drainage basins of the Little Blue, Republican, Smoky Hill and Solomon rivers.

The topography is characterized by bold bluffs of the Dakota sandstone and smaller benches of the harder Permian limestones and shales. There is one peculiar feature of the topography throughout the region: northern slopes of the divides are generally steep, while the southern slopes are very gradual, and often without rock exposures. The effect is as if the land had been tipped to the south, or as if there had been an interruption of a southeastern drainage which turned the master streams to the east, thereby causing the streams to erode their southern banks.

In regions of the Dakota formation, this often results in

an extensive series of low hills, composed entirely of loose sand, such as are seen in the vicinity of Abilene.

In the extreme northern part of the state, the country-rock is overlain by the glacial drift of the Kansan ice sheet. At the points where the contact crosses the Kansas-Nebraska line, the original topography and geology are obscured by drift, 60 to 100 feet in thickness, as observed from well borings.

GENERAL SECTION.

Pleistocene.—Glacial drift of Kansas sheet and loess (?) terraces.

Cretaceous.—Dakota formation, sandstones and clays.

Permian.—Limestones and shales.

Permian.—No attempt was made to distinguish between the formations of the Permian, but it was necessary to note such local aspects as would help in determining the contact line. There is everywhere an unconformity of considerable relief between the Permian and Cretaceous systems; which represents in time the Upper Permian, Triassic, Jurassic and Comanche Cretaceous.

The relief of this unconformity amounts, in places, to nearly 100 feet in the distance of a quarter of a mile. In one place (two miles northeast of Emmons, Washington county) there is a Permian monadnock which has patches of Dakota lying here and there on its sides, owing to erosion since Dakota times. This results in exposures of Permian above the level of the surrounding Dakota. Similar conditions on a smaller scale are found elsewhere.

Owing to this unconformity, the section of the Permian differs in places, the Permian having been eroded before the deposition of the Dakota to a lower horizon in some places than in others. The result of this is that the Permian is represented at the contact by different horizons, none of which are present over very large areas. At most places a series of thin-bedded limestones and shales was present at the contact, but in others a very porous limestone, evenly bedded red and yellow shales, or blue clay shales, represent the horizon of the Permian present at the contact. Over the whole area the Permian beds appear to be very evenly stratified.

The following section, taken from a cut on the Burlington railroad about two miles northwest of Hanover, Washington

county, shows a typical succession of the Permian beds of that region:

10.	Limestone, thin-bedded, and yellowish shales	5 ft.
9.	Limestone, massive	6 in.
8.	Shales, calcareous olive-gray, with limestone about four feet from bottom	16 ft.
7.	Limestone, grading through marly concretions to marly shales	1 ft.
6.	Shales, marly gray	4 ft.
5.	Shales, red, evenly bedded, with occasional indurated bands; in the lower portion are two layers of very impure semi-crystalline limestone or dolomite, apparently thrown down by precipitation. There are also four or five very thin layers of greenish shales	15 ft.
4.	Covered	10 ft.
3.	Limestone, two layers, separated by bluish shale; upper limestone hard	3½ ft.
2.	Shales, olive, indurated	4 ft.
1.	Shales, yellow calcareous and argillaceous limestone	2 ft.
	Covered slope below.	

The character of the Permian from a little different horizon is shown in a section from the north bank of Mill creek, near the middle of section 13, Charleston township, Washington county:

7.	Covered.	
6.	Limestone, light buff, cellular, rather thin-bedded	8 ft.
5.	Shales, bluish and yellowish	13 ft.
4.	Limestone, blue, laminated, fossiliferous	4 in.
3.	Shales, bluish	3 ft.
2.	Limestone, hard, buff, fossiliferous	8 in.
1.	Shale, blue, and covered slope to water level	17 ft.

Cretaceous-Dakota.—The prominent bluffs of this formation are composed of a deep-red or brown, rather coarse-grained, ferruginous sandstone. For this reason the formation is often spoken of as the Dakota sandstone, but this is a misnomer, as the bulk of the formation is probably not a hard sandstone, but clays and shales.[1] Other exposures vary greatly. In fact, it is hard to imagine a formation of a more diversified character. It gives much evidence of being a shallow-water deposit, such as would be formed along shores and in small estuaries by delta deposits, etc. Both the nature of the deposits and the fossil content bear out this statement. The land mass was probably a short distance east of the present eastern outcrop, as the Dakota becomes more evenly strat-

1. Gould. Trans. Kan. Acad. Sci., XVII, pp. 122-178. 1901.

ified to the west. The fossils consist of the leaves of such genera as Quercus, Sassafras, Salix, Ficus, Protophyllum, Platanus, Betulites, etc., all land plants.

Near the contact line the diversified nature is well shown. Yellow, red, brown and white sandstones are found, both consolidated and loose. These colors may be in separate layers or all in the same stone, in a space six inches square. In places a conglomerate predominates. In Charleston township, Washington county, about a quarter of a mile west of the line between sections 23 and 24, there are twenty-five to thirty feet of variegated, multi-colored clays, such as are typical of the Dakota a little west of Brookville, Saline county. The local name for this is "rainbow" clay, all the colors of the rainbow being jumbled into a variegated mass. There is no consistency in the structure in the easternmost outcrop of the Dakota. Within a quarter of a mile a road may cut through both a deposit of hard dark-red sandstone and a light-colored clay. In the sandstone cross-bedding is very much in evidence. In places large nodules of iron pyrites are found, while iron-oxide concretions of various sizes and shapes interest the inhabitants throughout the region.

The loose Dakota sands wash far down over the Permian and often obscure the contact.

As the sandstone is very porous, while the limestones and shales of the Permian are impervious, springs are found along the contact line and are helpful in locating it.

Pleistocene.—Glacial drift of the Kansan ice sheet. This formation overlies the five northern rows of townships in the region mapped. It is as diversified in character as the formations underlying it. Besides the sands and boulders of quartzite, greenstone, granite, etc., it is composed of fragments of Permian and Dakota rocks, the latter generally forming the bulk of the deposits. This is probably due to the fact that the Dakota formation extends some distance to the east in the region north of Kansas, thus lying directly in the path of the Kansan ice sheet. In the region of Hanover (and several other places) these materials have been cemented together into a conglomerate. Variegated clays and other clays, resembling those of the Dakota, have been deposited in places.

This causes some very perplexing problems in locating the contact in the drift-covered region. In the first place, it ob-

scures the underlying formations over large areas, and in the second, it contains deposits of clay, sand and conglomerate almost identical with those of the Dakota. However, if there are any wells present, the water will be hard in the drift and soft in the Dakota sandstone.

Other Deposits of the Pleistocene.—In much of the region along the west side of Mill creek in Washington county there are fifteen feet of very sandy, jointed clays, gray above and brown beneath, overlying the plain sloping towards the creek. This deposit may be due to the changes which seem to have been made in the direction of Mill creek in glacial times. The topography and geology suggest the possibility that Mill creek once flowed southeast from Washington, with a large branch from the north joining it just east of Washington, while a small stream used the present outlet of Mill creek into the Little Blue river. There is a channel beneath Greenleaf, nearly 100 feet deep and filled with glacial debris, as shown by the wells supplying water to Greenleaf. Along the railroad between Washington and Greenleaf there are no exposures of rock in place, but as the region was not carefully studied this evidence is not conclusive. Glacial damming of this stream in the region southeast of Washington may have formed a lake which sought an outlet to the north in the present valley of Mill creek.

If these suggestions are true, it was probably in this lake that these deposits were formed.

West of the Republican river at Clay Center the river bluffs are terraces composed of loess-like material with calcareous concretions, and native rock below. They rise to a height of forty to sixty feet at the edge of the river bottom, and are higher here than farther back. There is, as a rule, a fair back slope of the terrace to the hills of the Dakota to the west, and the junction is usually occupied by streams or branches of them and the drainage is away from the river down the terrace, which has a maximum width of three miles.

It may be that this deposit is the same material as that which is known as "plains marl" in the western part of the state. In regard to the latter, Professor Haworth[2] believes it to have had the same origin as that of the Tertiary mortar

2. Univ. Geol. Surv. of Kan., vol. II, p. 275.

beds, and thinks it probable that many of the properties of the plains marl are largely due to the action of wind.

In the region mapped the loess was found in valleys having a north-and-south direction. This may be due to the fact that a wind from the west, carrying the material, would deposit it in valleys lying north and south, while it would not accumulate in valleys having an east-and-west direction.

DISCUSSION OF THE MAPPING.

The mapping began at the Kansas-Nebraska line. Here the contact was concealed by 60 to 100 feet of drift. Just west of the Little Blue river, opposite Hollenberg, the Permian was exposed near the 1300-foot contour, while east of this town the Dakota rocks were exposed near the same level. Thus, in a general way, the contact is at the 1300-foot level between the state line and Washington west of the Little Blue. On the west bank of Mill creek there is a deposit of Pleistocene, covering the slope. The region is mapped as Cretaceous rock, though there is little doubt that it is material washed from the higher hills to the west. A tongue of Dakota extends north in the area between Mill creek and this river. If the suggestion that Mill creek formerly had its outlet to the south is true, this tongue would probably be an outlier.

On the east side of the Little Blue are outliers within six miles north and south of Hanover, but inside the boundaries of Washington county. South of Washington the contact rises nearly to the 1400-foot line, but west of that place pitches down, so that the Permian extends up Mill creek only two miles. The contact is found in the valley of Beaver creek, at an elevation of about 1375 feet. At Greenleaf, owing to the presence of the old channel noted above, neither Permian nor Dakota is exposed, but the former is only thirty feet below the level of the town a few miles east and west. Across this area the contact is dotted.

From Greenleaf to Clifton there is a continuous dip to the west. There is an outlier of Dakota in the vicinity of Chepstow, and it also extends south into the extreme northwest corner of Riley county, south of Kimeo. West from this point to Clifton the contact lies mostly in the northern row of townships of Clay county.

In the Republican valley the contact is concealed by a de-

posit of loess-like terrace material and alluvium, but a few miles east of Clifton it is found at the 1280-foot contour, and probably crosses the river about a mile southeast of Clifton. West of the Republican river the Dakota is found as a thin sheet on the terrace, as shown by well borings. Here the contact is at about the 1240-foot mark, but rises steadily to the south until the divide south of Manchester is reached, where a height of 1360 feet is reached. There is, however, a constant westward dip, so that the contact never extends very far west in the valleys of eastward flowing streams. In the region just described the contact passes near Idana, Oak Hill, Longford and Manchester.

East of the Republican river, in Clay county, the Dakota forms a large outlier about three miles northwest of Green. Here the contact is nearly up to the 1400-foot contour. From this outlier west to the Republican river the dip of the Permian is clearly and distinctly shown.

From Manchester to Abilene the Dakota lies on a narrow divide, but at its southern extension expands into a large area. In this area it is very thin, and disappears in a large expansion of sand hills, which may have originated from poorly lithified sandstone, or from stream or wind sediments.

From Abilene east to within three miles of Chapman, sand and sand hills occur on the north side of the Smoky Hill. There is much doubt as to the origin of these deposits. In this connection, the observations of Hay[3] in the vicinity of Junction City are interesting. He found sand hills near Junction City at or about the same level as those in the vicinity of Abilene. He says: "A more recent examination of the high-level sand dunes previously referred to revealed the fact that they are residual beds, resting on and abutting against undoubted outliers of the Dakota." Two areas of Dakota are shown on his map. These are only one-half of a mile west of the easternmost outcrops in Washington county, although the trend of the eastern outcrop of the Dakota is southwest throughout the state.

3. Hay. Geol. of Ft. Riley, etc., Bull. 137, U. S. G. S., p. 23.

CONCLUSIONS.

There is an unconformity of varying, but considerable, relief between the Permian and Cretaceous systems.

The eastern part of the Dakota sediments was deposited in shallow water along the shore and in estuaries and lagoons, as shown by the nature of the formation and the fossil content. Some of them may be of sub-ærial origin.

The shore-line of the Cretaceous sea was probably some distance to the east of the main body of the Dakota outcrop, as is shown by the presence of outcrops east of Hanover, Washington county, and in the vicinity of Junction City.